CLAIM AMENDMENTS

1. (Original) An ion sensing apparatus for detecting ion current in a combustion chamber of a diesel engine comprising:

a spark plug having electrodes for sensing ion current;

a shield integrally attached to the spark plug such that the shield is adaptable to protect the electrodes from direct impingement of fuel spray and engulfment of diffusive flame.

2. (Original) The ion sensing apparatus of claim 1 wherein the shield includes at least one induction orifice.

3. (Original) The ion sensing apparatus of claim 2 wherein the shield encloses the electrodes and forms a shielded space such that the diffusive flame is filtered through the at least one induction orifice to cause primarily premixed flame to occur within the shielded space.

4. (Original) The ion sensing apparatus of claim 1 wherein the shield comprises a shroud.

5. (Original) The ion sensing apparatus of claim 1 wherein the shield is further adaptable to be removed.

6. (Original) The ion sensing apparatus of claim 1 wherein the shield is sized such that a portion of the fuel spray directly impinges the electrodes.

7. (Original) The ion sensing apparatus of claim 1 further comprising a control module, the control module including an ionization module for detecting and analyzing the ion current and a plasma driver module for providing high energy sparks to the spark plug.

8. (Original) A method to cold start a diesel engine in accordance with the spark plug of claim 1 comprising the step of providing sparks to the spark plug located in a combustion chamber of the diesel engine wherein the energy of the sparks are of a sufficient magnitude to ignite the diesel fuel mixture in the combustion chamber.

9. (Original) The method of claim 8 wherein the step of providing the sparks to the spark plug comprises providing energy of a magnitude that keeps carbon build-up off ceramic surfaces of the spark plug.

10. (Original) The method of claim 8 further comprising the step of providing the sparks to the spark plug when combustion of the diesel fuel mixture has not begun on time.

11. (Original) The method of claim 10 wherein the step of providing the sparks to the spark plug when combustion of the diesel fuel mixture has not begun on time comprises the step of providing energy to the spark plug if combustion has not been sensed prior to a specified crank angle.

12. (Original) An ion sensing apparatus for detecting ion current in a combustion chamber of a diesel engine comprising:

a fuel injector; and

an ion sensing mechanism integrally attached to the fuel injector such that the ion sensing mechanism is protected against direct impingement of fuel spray.

13. (Original) The ion sensing apparatus of claim 12 wherein the ion sensing mechanism includes an electrode surrounded by a sleeve that is attached to the nozzle.

14. (Original) The ion sensing apparatus of claim 13 wherein the electrode is operable at a temperature sufficiently high enough to prevent the formation of electrically conductive contaminants on the surface on the electrode.

15. (Original) The ion sensing apparatus of claim 13 wherein the electrode is formed from Titanium Oxide.

16. (Original) The ion sensing apparatus of claim 13 wherein the sleeve is formed from a silicon nitrate wafer.

17. (Original) The ion sensing apparatus of claim 12 further comprising a sensor temperature feedback control in communication with the ion sensing mechanism.

18. (Original) The ion sensing apparatus of claim 17 wherein the sensor temperature feedback control includes a thermocouple.

19. (Original) The ion sensing apparatus of claim 12 wherein the fuel injector has a nozzle and wherein the ion sensing mechanism comprises:

a heating element attached to the nozzle; and

an ion sensing element adjacent to the heating element and adaptable to be attached to the heating element.

20. (Original) The ion sensing apparatus of claim 19 wherein the heating element is operable to keep the ion sensing element at a temperature sufficiently high to prevent the formation of electrically conductive contaminants on the surface on the ion sensing element.

21. (Original) The ion sensing apparatus of claim 12 further comprising a control module, the control module including an ionization module for detecting and analyzing the ion current and a driver module for providing current to ion sensing mechanism that is sufficiently high enough to prevent the formation of electrically conductive contaminants on the surface on the ion sensing element through resistive heating.

22. (Original) An ion sensing apparatus for detecting ion current in a combustion chamber of a diesel engine comprising:

a plasma discharge plug having electrodes for sensing ion current;

a shield integrally attached to the plasma discharge plug such that the shield is adaptable to protect the electrodes from a portion of direct impingement of fuel spray and engulfment of diffusive flame.

23. (Original) The ion sensing apparatus of claim 22 wherein the shield includes at least one induction orifice.

24. (Original) The ion sensing apparatus of claim 22 wherein the shield encloses the electrodes and forms a shielded space such that the diffusive flame is filtered through the at least one induction orifice to cause primarily premixed flame to occur within the shielded space.

25. (Original) The ion sensing apparatus of claim 22 wherein the shield comprises a shroud.

26. (Original) The ion sensing apparatus of claim 22 wherein the shield is further adaptable to be removed.

27. (Original) The ion sensing apparatus of claim 22 further comprising a control module, the control module including an ionization module for detecting and analyzing the ion current and a plasma driver module for providing high current to the plasma discharge plug.

28. (New) The ion sensing apparatus of claim 7 wherein the ionization module is adapted to detect at least one of start of combustion and combustion duration from at least one ion current signal.

29. (New) The ion sensing apparatus of claim 28 wherein the ionization module is adapted to detect the start of combustion by determining a location where the at least one ion current signal rises above a threshold value and indicating that the start of combustion is at the location where the at least one ion current signal rises above the threshold value.

30. (New) The ion sensing apparatus of claim 28 wherein the ionization module is adapted to detect the combustion duration by

determining a first location where the at least one ion current signal rises above a first threshold value;

determining a second location where the at least one ion current signal falls below a second threshold value; and

setting the combustion duration to the difference between the first location and the second location.

31. (New) The ion sensing apparatus of claim 21 wherein the ionization module is adapted to detect at least one of start of combustion and combustion duration from at least one ion current signal.

32. (New) The ion sensing apparatus of claim 31 wherein the ionization module is adapted to detect the start of combustion by determining a location where the ion current rises

above a threshold value and indicating that the start of combustion is at the location where the at least one ion current signal rises above the threshold value.

33. (New) The ion sensing apparatus of claim 31 wherein the ionization module is adapted to detect the combustion duration by

determining a first location where the at least one ion current signal rises above a first threshold value;

determining a second location where the at least one ion current signal falls below a second threshold value; and

setting the combustion duration to the difference between the first location and the second location.

34. (New) The ion sensing apparatus of claim 27 wherein the ionization module is adapted to detect at least one of start of combustion and combustion duration from at least one ion current signal.

35. (New) The ion sensing apparatus of claim 34 wherein the ionization module is adapted to detect the start of combustion by determining a location where the at least one ion current signal rises above a threshold value and indicating that the start of combustion is at the location where the at least one ion current signal rises above the threshold value.

36. (New) The ion sensing apparatus of claim 34 wherein the ionization module is adapted to detect the combustion duration by

determining a first location where the at least one ion current signal rises above a first threshold value;

determining a second location where the at least one ion current signal falls below a second threshold value; and

setting the combustion duration to the difference between the first location and the second location.

37. (New) A method to determine the start of combustion from at least one ion current signal comprising the steps of:

determining a location where the at least one ion current signal rises above a threshold value; and

providing an indication that the start of combustion is approximately at the location where the at least one ion current signal rises above the threshold value.

38. (New) A method to determine combustion duration from an ion current signal comprising the steps of:

determining a first location where the at least one ion current signal rises above a first threshold value;

determining a second location where the at least one ion current signal falls below a second threshold value;

determining a difference between the first location and the second location; and

providing an indication that the combustion duration is approximately equal to the difference.